# AIR RESOURCES LABORATORY

## Response to Research Review Team Data Request
## 6 February 2004

**Item 1.) PREVIOUS REVIEW.** A copy of the 2001 Review of the Air Resources Laboratory is attached, and has been transmitted electronically as a pdf file.

**Item 2.) HISTORY AND MISSION.** The Air Resources Laboratory emerged as the Weather Bureau's Special Projects Office in the early 1950s. It was formed to provide meteorological (especially dispersion) guidance to national security programs, mainly nuclear. The evidence of its beginnings is still noticeable. To this day, ARL serves as the source of atmospheric transport and dispersion capabilities to the National Weather Service, to NOAA as a whole, and to a wide range of external users (both national and international). Whereas the early focus was simply on the prediction of concentrations downwind of some specific emission source (e.g. a nuclear test), the dispersion skills have now broadened into many related areas of specialty. Out of the early awareness that radioactive fallout was a global issue grew the current activities related to climate and global change. From the need to consider the chemistry of pollutants arose the present emphasis on air quality and its prediction. From the recognition that mankind could modify the atmosphere on global scales came the ARL emphasis on climate and methods to detect changes in it. And from the awareness that pollutants are removed from the air through deposition processes came the ARL role in measuring and understanding wet and dry deposition and the growing activity in multi-media modeling of the whole environment. All of these activities are directly related to NOAA's core mission - the protection of people, the stewardship of the environment, and the prediction of changes in it.

**Mission Statement:** The Air Resources Laboratory conducts research on processes that relate to air quality and climate, concentrating on the transport, dispersion, transformation, and removal of trace gases and aerosols, their climatic and ecological influences, and exchange between the atmosphere and biological and non-biological surfaces. The time frame of interest ranges from minutes and hours to that of the global climate. The Laboratory provides scientific and technical advice to elements of NOM and other Government agencies on atmospheric science, environmental problems, emergency assistance, and climate change.

The specific goal of ARL research is to improve and eventually to institutionalize both current assessment and future prediction of atmospheric dispersion, air quality, deposition, and related atmospheric environmental variables, with full allowance for the roles of climate change and variability. It is the role of ARL, within NOAA, to conduct such research as is needed to improve (and expand, as necessary) NOAA's operational products. In addition, it is a role of ARL to make such measurements as may be required by the new capabilities being developed, and to safeguard the continuity of the observations that then evolve.

ARL operates with six research groups, each with its own research agenda but also each with a specific function within the ARL structure. The group at Oak Ridge, Tennessee, develops models to describe the processes of diffusion and deposition of pollutants. The group in Research Triangle Park, North Carolina, assembles the process understanding into coupled meteorology

and air chemistry models, for application in air quality programs of the Environmental Protection Agency and other organizations (e.g. states). A further role of the Research Triangle Park group is to extend its air quality modeling to the provision of real-time forecasts, and activity that calls for close collaboration with elements of the National Weather Service. The group at Idaho Falls, Idaho, specializes in conducting field studies to test the validity of dispersion models. At Silver Spring, Maryland, work concentrates on the development of dispersion models tailored for operational use, such as by the National Weather Service. At Las Vegas, Nevada, the dispersion capabilities are applied routinely in support of the nuclear missions of the Department of Energy. In recognition of the fact that new models require increasingly more information on the surface energy budget, the group in Boulder, Colorado, operates research-grade measurement stations where the surface radiation balance is documented. In whole, the set of ARL field offices constitutes an end-to-end model development, testing, and implementation capability. The success of the process is well illustrated by the fact that many models developed by ARL scientists are now fully operational, in DOE and the EPA as well as in the service Line Offices of NOAA.

**Item 3.) MAJOR CUSTOMERS.**

NWS. ARL provides models and expertise related to the provision of forecasts of air quality and dispersion.

NESDIS. ARL serves as the agent for developing, instrumenting and operating the Climate Reference Network of NESDIS.

NOS and NMFS. ARL provides the capability to quantify rates of atmospheric deposition to coastal ecosystems.

NASA. ARL leads the meteorology and dispersion panel of the Interagency Nuclear Safety Review Panel, which examines the safety of all space missions involving radioactivity, on behalf of the White House.

EPA. ARL provides the brunt of the models used for air quality policy, control strategy, and regulation development, and serves as the authority to approve use of other models.

DOE – Nevada. ARL provides meteorological and atmospheric dispersion expertise to the Nevada Test Site and to all related national security programs.

DOE – Idaho Falls. ARL provides dispersion and emergency management capabilities to the Idaho National Engineering and Environmental Laboratory.

DOD. ARL provides dispersion products to many DOD agencies, addressing issues of national security and homeland security.

USFS. ARL provides the dispersion modeling capability on which new USFS forest fire smoke plume models are being constructed.

USDA. ARL operates the UV calibration facility, used to calibrate all UV radiometers used in US networks. (Note, Smithsonian, NOAA, NSF, EPA as well as USDA.)

WMO (World Meteorological Organization). ARL provides the Quality Assurance program to assure the intercomparability of all precipitation chemistry data, collected globally.

IAEA (International Atomic Energy Agency). ARL (with NCEP) serves as the Regional Specialized Meteorology Center for dispersion prediction in the Americas.

CTBTO (Comprehensive Test Ban Treaty Organization). ARL provides the transport and dispersion capability on which CTBT programs rely.

**Item 4.) SUMMARY OF RESEARCH.** ARL research is fundamentally matrixed, since all programs relate to the interactions between the air and other components of the environment. In ARL research, the air is viewed as a resource that is at risk.

**4a.) Relationship with NOAA program areas.** The three major areas of ARL research parallel those of NOAA and of OAR – "Weather and Water," "Climate," and Coastal and Ecosystems." Within these three major areas of ARL research, long-term goals can be identified as follows. In each case, the anticipated time frame is about 15 years.

***Weather and Air Quality***

Provide demonstrated computer codes for describing emission rates of trace gases and aerosols from natural surfaces, both vegetated and otherwise, and deposition rates to them.

Provide accurate measures of emission and deposition rates, based on routine network observations (such as by AIRMoN).

Provide fully Eulerian and hybrid Lagrangian methodologies for forecasting the downwind dispersion of chemicals generated by fires and injected by other mechanisms into the atmosphere from point or local area (sub-grid cell) sources.

Provide the basis for a NOAA operational dispersion forecasting product for protecting the public and society from the consequences of releases of chemical, biological, and radioactive agents into the atmosphere.

On the basis of field studies by small aircraft carrying advanced meteorological instrumentation, provide a sound basis for incorporating sub-grid scale variability of air-surface exchange in mesoscale and other numerical models.

***Climate***

Maintain operations of and continued improvement on the Climate Reference Network.

Maintain operations of the Quality Assurance Center for atmospheric aerosols and their

deposition as a contribution to the Global Atmosphere Watch of the World Meteorological Organization.

Provide concise descriptions of atmospheric climate trends, through analysis of radiosonde and other routine meteorological measurement programs.

***Coastal and Ecosystems***

In conjunction with other agencies, provide multi-media models to permit accurate examination of societal costs and benefits associated with specific pollution regulatory and control actions, as input to the Department of Commerce and the federal administration.

Provide detailed information on the rate at which the atmosphere delivers pollutants to coastal and other (e.g. coral reef) ecosystems.

**4b.) Geographic scope.** ARL Weather and Water research is necessarily widely applicable. It is considered global in potential scope. Climate research is also considered to be global. However, in both cases there are regional and local aspects that are receiving specialized attention. ARL Coastal and Ecosystem research is focused mainly on the Atlantic and Gulf coasts. Note that ARL research groups are located in Silver Spring, MD; Research Triangle Park, NC; Oak Ridge, TN; Idaho Falls, ID; Las Vegas, NV; Boulder, CO. There is also an ARL presence with research groups in Davis, WC; and Annapolis, MD.

**4c.) Research Time Frames.** ARL research expertise relates to the quality of air and the interaction of the atmosphere and other elements of the environment (including people). Research activities spread over a broad range of time scales. ARL scientists address immediate needs of NOAA Line Offices and other agencies, with transfer to operations a specific and recognized goal at the outset. ARL research also anticipates future operational developments, over time scales of five to fifteen years. The ARL Strategic Plan outlines short-term and long-term goals, in a manner that permits examination and involvement by individual scientists. Often, it is the same scientists who are addressing both immediate needs and long-term goals. Five year goals (presently being refined) are as follow.

***Weather and Air Quality***

a. An Operational Air Quality Forecasting System.
   -- Evaluate fully Eulerian and Hybrid forecasting systems.
   -- Engage the private AQ forecasting community in joint development activities
   -- As determined by the OAR/NCEP collaboration, continue operationalizing models .
   -- Work on improving forecast skill as an ongoing process.

b. Local and Urban Dispersion Models
   -- Complete analysis of data from the Oklahoma City study.
   -- Develop a new tracer sampling and analysis system.
   -- Implement the Washington testbed.
   -- Integrate Washington testbed activities with the DC Emergency Management Agency.

-- Advance the testbed approach to other locations, starting with New York City.
-- Institutionalize a national dispersion forecasting system for local application.
-- Working with DTRA and other agencies, plan and conduct dispersion field studies.
-- Promote and conduct physical laboratory studies of dispersion processes

c. Regional and Longer Range Plume Prediction Model
-- Deliver a volcanic ash version of HYSPLIT to NWS/NCEP.
-- Conduct relevant training sessions.
-- Complete systems integration with NESDIS for access to dual use data.
-- Couple improved forest fire source term algorithms with plume models.
-- Extend forest fire forecast capability to chemical composition.
-- Deliver a refined HYSPLIT forest fire smoke forecast system to USFS
-- Improve and verify transbounday transport and diffusion models
-- Refine source-receptor understanding for a range of atmospheric pollutants.

d. Air Quality and Deposition Field Programs
-- Continue the ETOS series of studies.
-- Formalize interagency relations related to ETOS.
-- Institutionalize studies of the southeast within the NOAA air quality program.
-- Extend atmospheric mercury studies to other locations
-- Refine methodologies for quantifying dry deposition
-- Develop new instrumentation and collectors for wet deposition
-- Develop techniques for interpolating among measurement locations

***Coastal and Ecosystems***

a. Integrated Media Studies
-- Complete the mid-Atlantic highland (Canaan Valley) monitoring site.
-- Assess nitrogen deposition rates to the upper watershed of the Chesapeake Bay.
-- Assess nitrogen deposition rates to the Delmarva Peninsula.
-- Complete the nitrogen cycling study of Tampa Bay and its environs
-- Work with Sea Grant and NOS to generate complete pollutant balances for a demonstration watershed(s).
-- Refine models of areal deposition and apply to selected estuaries-- e.g. the Neuse River and the Chesapeake Bay.

b. Air-Sea Interaction Studies.
-- Work with other agencies to study air-sea interaction in light and high wind conditions
-- Develop instrumentation to measure air-sea exchange rates in extreme conditions.

***Climate***
-- Complete Climate Reference Network installations at all SURFRAD sites.
-- Institutionalize formal QA/QC programs for the CRN.
-- Complete examination of precipitation sensors for CRN deployment.
-- Complete examination of humidity sensors
-- Formalize aerosol optical depth algorithm for multi filter rotating shadow band

radiometers..
-- Investigate trends in key atmospheric variables, and understand linkages with air quality, surface energy balance, etc.
-- Formalize association and alignment with GCOS/GAW.
-- Institutionalize association with NCEP, requiring routine SURFRAD' data.
-- Develop methods for detecting slow trends in poorly observed atmospheric variables.
-- Assess changes in air quality and atmospheric deposition due to climate change.
-- Understand the behavior of ecologically important atmospheric chemicals in sensitive regions, e.g. mercury in the Arctic.
-- Study CO2 sequestration and explain the causes of year-to-year vaiability.
-- Quality assure AMERIFLUX and FLUXNET data obtained by NOAA/ARL.
-- Examine methodologies for spatal interpolation using light aircraft flux systems.
-- Examine linkages between CO2 sequestration and related climatic variables.
-- Assemble annual summaries of national and continental CO2 sequestration.

**Item 5.) MAJOR ACCOMPLISHMENTS.** There is an impressive list of major accomplishments that forms part of the ARL Strategic Plan. The following items are excerpted from this list.

***1. Air Quality Modeling.*** The third generation air quality assessment model (MODELS-3/CMAQ) has now been adopted as the mainstream air quality assessment tool for use in regulatory and control applications in the USA. In the last year, it has been adapted for coupling with the NWS ETA model system, so as to provide the entry-level air quality forecasting model soon to be used operationally by the National Weather Service in partnership with the Environmental Protection Agency. This development is facilitated by the recently signed Memorandum of Understanding on Research between EPA and NOAA, and the associated Memorandum of Agreement on Air Quality Forecasting,

***2. Urban Dispersion.*** The recent recognition of the vulnerability of American population centers to terrorist attack caused the rapid development and deployment of dedicated turbulence measuring systems across the Washington, DC, downtown area, in support of specialized forecasting of dispersion in this particular urban area. The activity has now been extended to address New York City. This DCNet work is widely seen as a centerpiece of the emergency management capability now in place in the Nation's capital. The research that accompanies the deployment of the instrumentation is rapidly leading to the development of new high-technology systems for forecasting dispersion in other urban areas, not only in Washington. Trial systems have been deployed at Weather Service Forecast Offices and in several emergency management centers. In parallel activities, ARL has vastly improved its capabilities related to the use of atmospheric tracers, and has provided the related skills and field expertise at the first two of the modern sequence of urban experiments - Salt Lake City and Oklahoma City. This activity will provide a vastly improved capability to protect the public in the event ora terrorist attack.

***3. Mercury in the Environment.*** Mercury emitted from coal burning and other sources remains in the air for an extended period, until transformed into chemical forms that are soluble and are therefore easily deposited to the surface. ARL science over the last two years has helped identify the chemical processes that lead to this transformation, especially at high latitudes where the deposition of mercury is especially important (because it accumulates in mammals that are part of the food chain of humans). ARL models have addressed the transport and transformation of

mercury in air, and have been used at a policy level to help identify regional origins of mercury that could be curtailed. The issue of growing importance, since increasing reliance on fossil fuels in developing countries is rapidly elevating levels of mercury in air, with potentially severe consequences to US fish stocks.

***4. Flux Measurement Systems and Aircraft Programs.*** Following a decade of development using small research aircraft, the ARL Mobile Flux Platform has been adapted for use in hurricane research using the P-3 aircraft. The system, with its infrared gas analyzer system for measuring carbon dioxide exchange rates with the surface, is now standard equipment on Sky Arrow aircraft used for atmospheric research. Expansion of the ARL aircraft program is now anticipated, with the proposed addition of a Velocity aircraft to the NOAA fleet. Similar flux measuring systems have recently been deployed at ground stations, to provide surface benchmarks for future assessments of regional water cycles and carbon dioxide sequestration.

***5. Climate Programs -- "Integrated" Monitoring.*** ARL has steadfastly advocated the adoption of the principles of integrated monitoring in its research activities, strongly promoting the collocation of various measurement programs and the integral coupling of measurements with ongoing research and interpretation. The focus of ARL ongoing "quasi-operational" measurement programs is on the interaction between the atmosphere and the surface, and the extraction of meaningful climate data from other than specialist sources of data. These climate activities extend beyond the atmosphere alone. They also address aspects of ecosystem behavior such as water quality. ARL components of this monitoring activity address the exchange of radiation components, and of water, heat, momentum, carbon dioxide and various trace chemicals (the last in the Atmospheric Integrated Research Monitoring Network). A parallel part of this program couples ARL sensor technology research by (a) supporting the development of the Climate Reference Network and (b) the extraction of climate trends and variability data from routine radiosonde and ozone observations.

**Item 6.) LEGAL MANDATES.**

- H.R. 4 Energy Policy Act of 2002 (Senate Amendment) S. 517, Part II, Section 1383, Forecasts and Warnings "The Secretary of Commerce, through the Administrator of the National Oceanographic and Atmospheric Administration, shall, in order of priority as listed in section (c), conduct regional studies of the air quality within specific regions of the United States. Such studies should assess the effects of in situ emissions of air pollutants and their precursors, transport of such emissions and precursors from outside the region, and production of air pollutants within the region via chemical reactions." "The Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, shall, in order of priority as listed in section (c) establish a program to provide operational air quality forecasts and warnings for specific regions of the United States…" (regions listed span continental U.S., Alaska, and Hawaii).

- Memorandum of Understanding between NOAA and EPA signed by the Deputy Secretary of Commerce and the Administrator of EPA (May 2003) reaffirmed the ongoing collaboration between EPA and NOAA in the conduct of research and related to the origins, dispersion, transformations, and deposition (transfer of gases and particulates from the air to the underlying land/water surface) of air pollutants, and expanded this

collaboration to include related research that addresses the shared interests of both Agencies. This collaboration will help ensure that the most recent and scientifically credible meteorological knowledge, focusing on the formation, transformation, transport and dispersion of contaminants through the atmosphere and their removal from the atmosphere is available for predicting future air quality, and for assessing, developing scientific reasons for environmental decisions, both in the atmosphere and in the context of the aquatic and terrestrial biospheres.

- Memorandum of Agreement between NOAA and EPA signed by the Deputy Secretary of Commerce and the Administrator of EPA (May 2003) expands the partnership to include air quality forecasting. NOAA deliverables include improved air quality forecast models and air quality forecast guidance. EPA deliverables include providing emissions inventory and monitoring data.

- The "Great Waters" Section of the 1990 Clean Air Act Amendments (Section 112(m), Title III) (m) Atmospheric Deposition to Great Lakes and Coastal Waters- Deposition assessment.- The [EPA] Administrator, in cooperation with the Under Secretary of Commerce for Oceans and Atmosphere, shall conduct a program to identify and assess the extent of atmospheric deposition of hazardous air pollutants (and in the discretion of the Administrator, other air pollutants) to the Great Lakes, the Chesapeake Bay, Lake Champlain and coastal waters.

- Section 901, j, of Title IX of the 1990 Clean Air Act Amendments - Continuation of the National Acid Precipitation Assessment research program identifies participating agencies – "The Acid Precipitation Task Force shall consist of the Administrator of the Environmental Protection Agency, the Secretary of Energy, the Secretary of the Interior, the Secretary of Agriculture, the Administrator of the National Oceanic and Atmospheric Administration, the Administrator of the National Aeronautics and Space Administration, and such additional members as the President may select." The President selected NOAA to lead this Task Force.